DEPSCoR FY 99
Use of Stochastic Modeling of Stratigraphic Relationships in High Resolution Seismic Reflection Data for Prediction of the Distribution of Acoustic and Geotechnical Property Variability in Near Surface Sediments on the East China Sea Continental Margin

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LONG-TERM GOALS

Our research group is collecting and analyzing various levels of high resolution seismic data and cores, for ground-truthing seismic facies, on continental margins with a spectrum of depositional boundary conditions. The long-term goal of this work is develop stochastic models of variation of geotechnical and seismic property distribution on margins subjected to a spectrum of depositional regimes. The importance of being able to produce these stochastic models is that it provides a means of making predictions (with assignment of statistical risk) of the variation of geotechnical and seismic properties in areas where the only data that may exist for that margin at the time that a prediction is needed is information on physical oceanography or other gross descriptions of depositional conditions on the margin.

OBJECTIVES

- Collect high-resolution seismic data on a margins with extreme depositional boundary conditions with objective of subjecting these data to sequence stratigraphic and seismic facies analyses to characterize the magnitude of the impact of variation in depositional regime on seismic stratigraphic architecture and seismic facies distribution.
- Quantify the nature of horizontal and vertical seismic facies heterogeneity within a sequence stratigraphic context, and develop stochastic models of seismic facies heterogeneity produced under depositional conditions described above
- Assess the impact of the depositional processes from margins with extremely different boundary conditions on the stochastic models of vertical and horizontal distribution of seismic facies (and therefore geotechnical and acoustic properties)
- Determine the minimum data required to predict the distribution of seismic attributes on margins with various depositional boundary conditions by conducting sensitivity tests on survey spacing and associated changes in the distribution of mapped parameters.

APPROACH

University of North Carolina Seismic Stratigraphy Group (UNCSSG) is researching the relationships between variations in sedimentary boundary conditions and the stratigraphy produced by these

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conditions. Limited work has been conducted on relating distribution of near-surface seismic facies and variability in depositional environment boundary conditions. The study area on the Western Pacific Continental Margin (WPCM) is a region with high sediment supply (4 times the amount of sediment per year as the Mississippi River) and large magnitude hydrodynamic sediment transport processes (tidal currents and large waves from typhoons and storms associated with the winter monsoon), so that there may be a high degree of correspondence between the sedimentary processes active on the margin and the preserved stratigraphy. In other words it may be a situation where the sedimentary processes and recent stratigraphy may be in dynamic equilibrium. This situation may be rare today and it may be an "End-Member", but understanding this system is essential to understanding systems where the record of sedimentation is much less complete. In fact this area contrasts quite distinctively with many other continental margins (such as offshore Alabama, offshore Eel River, California, or offshore New Jersey). Thus far our attention has been focused on the inner and middle shelf environments. This investigation involves acquisition and analyses of data from the outer shelf and slope environment of the ECS. Therefore when this investigation is complete we will have characterized the entire margin.

UNCSSG is simultaneously completing an investigation of the 3-D variability of an area (the Alabama Shelf) with low sediment supply, microtidal conditions, and relatively infrequent storm events. Approximately 2,125 km of high-resolution (<1 m) Geopulse reflection seismic data were acquired within a 900 km^2 grid in an area that extends from • 5 km offshore of the Alabama coast to the upper continental slope. We are developing probability models of the distribution of seismic facies variability in this area and determining the minimum data density required to successfully make predictions of physical property distribution given the set of boundary conditions described above.

The approach for this project is to: (1) acquire data from environments with a history of extreme depositional boundary conditions, (2) conduct sequence stratigraphic analyses of these data to identify units deposited within the same interval of time, and (3) conduct quantitative seismic facies analyses on the data sets so that the variations in seismic facies within each time-slice can be tracked spatially and later subjected to Analysis of Variance, Q-mode factor and binomial markov process analysis to identify non-random variations in seismic facies variability. We will also investigate the utility of Fuzzy Logic in characterizing spatial variability of seismic facies in this system. This provides the stochastic model of spatial variability in acoustic property variability on the continental margin. We then test for sensitivity to survey spacing by under and over sampling isochron maps of seismic facies and thickness of systems tracts at various intervals, overlaying the maps, measuring deviations in orientation of features, and their spatial magnitude and conducting statistical tests to determine when the differences are significant. We are conducting similar analyses when comparing the near-surface sonar facies distributions of the “end-member” continental margins.

We also recently acquired an “Acoustic Core” seismic processing system that we used to calibrate our chirp and seismic data so that we can compute variations in velocitiy, density, impedance, reflectivity, and attenuation with depth. Results of these analyses will be integrated with the results of stochastic analyses of seismic facies so that we can use these investigations to produce models of variation of physical property distribution on continental margins.

WORK COMPLETED

- This year has primarily been a data acquisition year. We most of our time time planning the surveys, ordering consumables, and arranging transport of our equipment to and from the western

Pacific port, and collecting data for two months at sea. We were at sea nearly all of May and June of 1999 collecting data. During survey 221099 in the East China Sea (ECS) and the Yellow Sea (YS) we collected 191 km of 210 cubic inch Generator Injector Air Gun data, 3,502 km of 15 cubic inch water gun data, 3,217 km of chirp and side-scan sonar data, and 6 cores. During survey 221199 in the outer continental shelf and slope of the ECS margin we collected 2,575 km of 50 cubic inch Generator Injector Air Gun data, 1,723 km of 15 cubic inch water gun data, 2,061 km of chirp and side-scan sonar data, and 11 cores This brings our total data set from the ECS continental margin to 13,643 km of seismic data, 11,530 km of chirp sonar, and We returned from the surveys in early July 51 cores. We anticipate receiving the original digital data from the survey back from the Naval Oceanographic Office during the first week of November 1999. We were successful at doing most of the processing of the seismic data while at sea so we anticipate that we will be able to start seismic stratigraphic and facies analyes very soon.

- Upon completion of the seismic stratigraphic and facies analyses we will begin our stochastic analyses of the data set. Analysis of spatial variability of subsurface acoustic attribute of chirp sonar data collected on cruises 221099 and 221199 (reflection coefficients and attenuation coefficients) our Acoustic Core system. New chirp seismic and sonar data collected in the WPCM study area new cores will be integrated into an analysis of the entire region. Analyses of relationship of facies distribution with variations in depositional boundary conditions (from published literature) will be conducted on the data as well.
- The data collected during the 99 surveys reduces the lateral interval between existing profiles on the ECS margin. These data will be integrated with the existing data sets and sensitivity tests on impact of survey profile spacing on successful prediction of property distribution on ECS will be conducted.
- We will continue with our comparison of results of stochastic models from margins with extremely different boundary conditions to assess the impact of the processes on development of stratigraphic architecture and distribution of near-surface acoustic and geotechnical properties.

RESULTS

Acquisition of 191 km of 210 cubic inch Generator Injector Air Gun data, 3,502 km of 15 cubic inch water gun data, 3,217 km of chirp and side-scan sonar data, and 6 cores in the East China Sea (ECS) and the Yellow Sea (YS) during survey 221099. During survey 221199 in the outer continental shelf and slope of the ECS margin we collected 2,575 km of 50 cubic inch Generator Injector Air Gun data, 1,723 km of 15 cubic inch water gun data, 2,061 km of chirp and side-scan sonar data, and 11 cores

IMPACT/APPLICATIONS

The scientific impact of this work is that it quantifies relationships between depositional boundary conditions and near-surface seismic/geotechnical properties distribution on continental margins. This therefore leads to more reliable estimates of these properties in areas where it is either difficult to acquire such data, or it is necessary to design a survey that will quickly provide needed insight, with a given level of risk of a bad prediction. It also leads to more successful design of transmission loss surveys and acoustics experiments on the role of bottom interaction on sound propagation in continental shelf environments. This obviously has impact in areas such as oil and gas exploration and production, environmental waste containment, and of course defense related issues on continental margins.

TRANSITIONS

Understanding the process-response relationship between depositonal conditions and seismic facies distribuition leads to improved understanding the nature of the heterogenity of the distribuiton acoustic properties on a continental margin. The Naval Oceanographic Office has used the results of our analyses to design and conduct more successful transmission loss surveys and modeling of sound propagation on the WPCM.